which is caused by two or three turnings of the handle H_1.

To close the valve, the disk is positioned at II by the handle H_1, and then on turning the handle H_2 it is pressed against the rubber gasket R_1 by the three rods P_1, P_2, P_3, which move keeping pace with each other.

The valve is opened by the reverse operations.

The remarkable features of this valve are as follows :

1) By the utilization of the gravity the mechanism is very simple, and we call it "seesaw" disk valve.

2) The necessary strokes of the handle H_1 and pushing rods P's are very small, and almost independent of the valve size.

3) For the vacuum seals of all the movable part sylphon bellows are used.

4) Simple in construction and compact in size.

From these features, this design seems also favourable for extremely large vacuum valves.

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3. Poly-phase Vibrating Reed Driven by Piezoelectric $BaTiO_3$ Ceramics

Kiyoshi ABE, Tetsuro TANAKA, Toshio INOGUCHI and Akira MURATA

(Abe Laboratory)

In the previous report (This Bulletin, **31**, 421 (1953)) about piezoelectric type vibrating reed, the following two merits were pointed out and confirmed by experiments.

(i) The material of vibrating reed has not always to possess ferromagnetic property.

(ii) As piezoelectric elements were directly adhered on the surface of vibrating reed, supporting device becomes very simple.

These merits also seem to be useful for the pourpose to generate the polyphase oscillation by vibrating reed.

In the first place, three phase vibrating reed was constructed and investigated, the result of which will be described here.

Three phase vibrating reed driven by $BaTiO_3$ ceramics.

To produce the polyphase oscillation by mechanical vibrator, it is necessary that the vibrator is axially symmetric, and the most ideal form seems to be lanky column. But since plane surfacf is desired to which piezoelectric elements are adhered, a hexagonal prism was adopted in this experiment.

Fig. 1 shows the plane development of hexagonal prism for the sake of explanation. At the nodal position, two groups of piezoelectric elements (A_1 B_1 C_1, A_2 B_2 C_2) were adhered and two grnups of supporting holes (D_1 E_1 F_1, D_2 E_2 F_2) were drilled. One group of elements (for example A_1 B_1 C_1) works as driver, and another (A_2 B_2 C_2) works as pick up. Six herical springs were soldered in supporting hole, and a reed was supported by these springs in the frame. The dimension of $BaTiO_3$ elements which were adhered to this reed were $3\times6\times0.3$ mm.

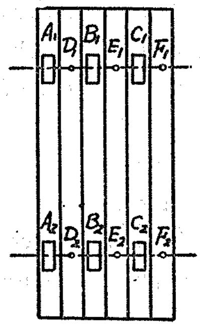

Fig. 1.

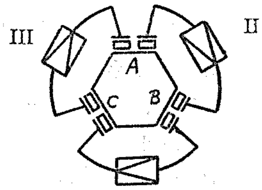

Fig. 2.

Fig. 2 shows the block diagram of oscillating circuit, where I, II and III are three sets of amplifier that has equal characteristics. As the inner loss of the reed of this type is approximately 25 db., the gain of amplifier must be greater than this value. In this experiment two stage amplifier which consists of 6C6-6ZPI was used. Two groups of elements (A_1 B_1 C_1 and A_2 B_2 C_2) were polarized in opposite direction.

Experimental result

The natural frequency of bending vibration of reed is represented by the following equation,

$$\omega_m = \frac{a_m^2}{l^2} \cdot R \cdot \sqrt{\frac{E}{\rho}}$$

where $a_m = 4.73$ for fundamental

$= 7.8532$ for second harmonics

R : radius of gyration of area concerned with neutral plane.

For hexagon

$$R = \frac{\sqrt{5}}{\sqrt{24}} \cdot a$$

where a is the length of one side of hexagon.

As the specimen employed for this experiment has the values

$E = 2.0\times10^{12}$ dyne/cm

$\rho = 7.86$

$l = 6.55$ cm

$a = 0.3$ cm

natural frequencies are calculated from these constants as follows:

$$f = 5733 \text{ c/s} \quad \text{for fundamental}$$
$$= 15749 \text{ c/s} \quad \text{for second harmonics}$$

But experimental values were 5670 and 15180 c/s respectively.

At first, differences about 10 c/s were found between natural frequencies in three directions, so it could scarcely generate three phase oscillation. After taking away this unbalance, approximately symmetrical three phase oscillation was obtained.

Observing the phase angle by Braun tube between the output of any two amplifiers of the oscillator, difference of about 120° was found in any combination.

Another experiment was carried out; namely, adhering a small mirror on the end surface of the reed and magnifying the motion of this portion by means of light lever, it was observed that the locus of light spot drew a circle on the screen.

From these two results, it was proved that three phase vibration can easily be excited by such method.

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4. Study on High Dielectric Constant Ceramics. (XXII)

The Modes of Vibration about Langevin Type $BaTiO_3$ Ceramic Virator. (2)

Kiyoshi ABE, Tetsuro TANAKA and Akira KAWABATA

(Abe Laboratory)

It was reported in part 1 (This Bulletin, **31**, 295 (1953)) that, in resonant condition, the amplitude distribution on the vibrating surface of the cylindrical Langevin type vibrator which has the resonant frequencies at about 50kc and 75kc, was measured by a small piezoelectric type pick-up which has the structure of Langevin type, and modes of vibration were presumed by the result of obtained. Recently, the acoustic directional characteristics of the vibrator were measured in the water and it was shown that these results agree well with our presumption except one for the directional characteristics on the second resonance (75kc). The measured directional characteristics has a minimum at the center and assumes the curve similar to butterfly (Fig. 4). The study were carried out in order to solve this inconsistency, which will be described here.

Method and Result of Measurement.

In Part 1, it was assumed that the vibration of Langevin type vibrator was symmetric on both sides of piezoelectric material and the measurement was carried on upper half of the vibrator. The directional characteristics about the second resonance measured in water suggest that the phase relation between the upper and lower part is opposite to each other. So in this study, phase relations and exact amplitude distri-